PRODUCT INNOVATION

Power-Conversion Chip Cuts Energy Wastage In Off-Line Switchers

High-Voltage Controller Enables Energy-Efficient, Economical Alternatives To AC Wall Adapters And Standby Power Supplies.

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While the efficiencies of power-conversion chips and power sources continue to improve, energy wastage in stand-by mode remains astonishingly high. For example, ac wall adapters are still plugged in and consume power, even though gadgets like TVs, VCRs, and cordless phones are supposedly off. And, the problem is expected to worsen as more electronic consumer products pervade the home.

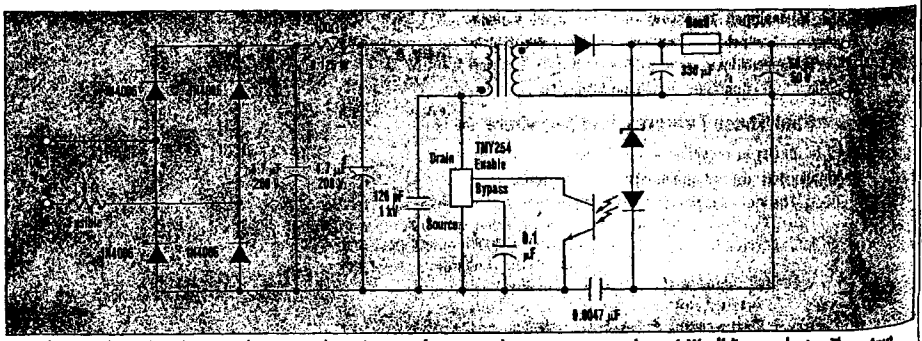
This wasted energy costs money, as well as contributes to pollution. According to a study conducted by Lawrence Berkeley National Laboratory, Berkeley, Calif., in the U.S. alone, consumers pay over $3.5 billion annually to keep a variety of electronic widgets in stand-by mode. To curb such wastage, several energy-saving guidelines have been established around the world. The U.S. Energy Star program, for example, has been extended to consumer electronics, with efforts underway to cover home audio and DVD players. Likewise, Germany's Blue Angel legislation is catching momentum in Europe.

To enable a new class of energy-efficient off-line ac adatpers and stand-by power supplies, Power Integrations Inc. has crafted a radically new switcher solution for low-power (10 W and below) applications (*Fig. 1*). And, at the heart of this solution is a proprietary controller chip called TinySwitch.

"This new design reduces the energy wastage from the 1.2 W (typical) seen in today's conventional, linear, ac wall adapters (or bricks) to less than 100 mW," says Shyam Dujari, director of marketing at Power Integrations. Plus, he adds, it provides a compact, light-weight adapter or stand-by supply with universal input. Because fewer low-cost external components are needed with this solution, the total system cost is also significantly cut, notes Dujari. By comparison, pulse-width-modulated (PWM) based off-line switchers are bulky and cost more, according to Dujari.

Designed to be a simple, on/off control device, the TinySwitch integrates on-chip a 700-V power MOSFET; oscillator; high-voltage, switched-current source; current limit; and thermal shutdown circuitry (*Fig. 2*). Unlike the conventional PWM controller, it uses an on/off control to regulate the output voltage. In this scheme, when the on-chip oscillator is enabled, it turns the power MOSFET on at the start of each cycle. The MOSFET is turned-off as soon as the output current reaches the upper limit.

The maximum on-time of the power MOSFET is determined by the duty cycle signal (D_{MAX}) of the internal oscillator. Also, the current limit and switching frequency for a given TinySwitch is fixed, while the power delivered is proportional to the primary inductance of the transformer. Because the TinySwitch is powered directly by the incoming high voltage, it eliminates the need for an auxiliary bias winding and associated circuitry, thereby simplifying the design of the transformer. In fact, the manufacturer recommends standard, low-cost transformers based on ferrite cores like



1. As shown in the application circuit, the TinySwitch requires very few external components to complete a 4-W, off-line ac adapter. The output power is proportional to the primary inductance of the transformer, and is independent of the input voltage.

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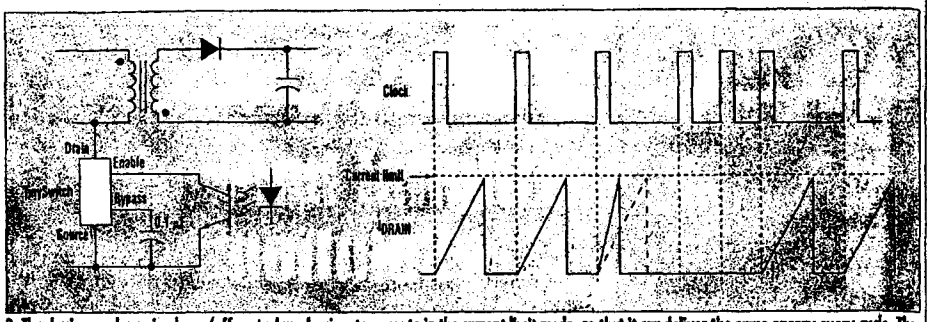


3. The device employs simple on/off control mechanism to operate in the current limit mode, so that it can deliver the same energy every cycle. The current-limit operation rejects line-frequency ripple. The current limit and clock cycle for each device is fixed.

EE16, which is available from multiple sources.

Novel Operation

The very-high loop bandwidth of the device provides excellent transient response and fast turn-on, with practically no overshoot, claims Dujari. As per the data sheets, the turn-on time is about 1.0 ms at no load. Plus, he adds, the fixed current-limit operation rejects the line ripple, as the energy delivered is independent of the input voltage (*Fig. 3*). Other features include glitch-free output when the input is removed, and thermal protection. No loop compensation is needed. The thermal shutdown threshold is set at 135°C, with 70°C hysteresis. Consequently, when the junction temperature exceeds 135°C, the power MOSFET is disabled. It remains disabled until the die-junction temperature goes under 70°C, at which point it is re-enabled.

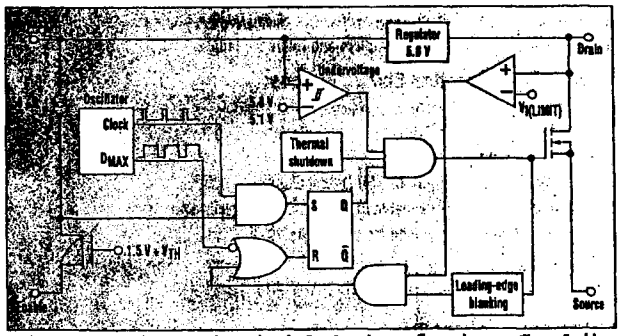
Under no-load condition, the TinySwitch consumes only 30 to 60 mW at 115/250-V ac input. As a result, stand-by supplies based on the TinySwitch can meet Blue Angel, Energy Star, Energy 2000, and European cellular phone standards. This smart integration of a high-voltage MOSFET switch with low-voltage control and protection functions is made possible by the company's proprietary CMOS process.

The TNY253/254/255 are the first three members of the TinySwitch family. Aimed at TV/VCR stand-by solutions, the TNY253 is rated for 5-W supplies. Likewise, TNY254 delivers up to 8 W for cellular phone chargers and PC stand-by supplies. Both the TNY253 and TNY254 switch at 44 kHz to minimize EMI filtering requirements, and permit the use of a simple snubber clamp to limit drain spike voltage.

However, the TNY255 uses a higher-switching frequency of 130 kHz to deliver up to 10 W for applications like cell phone chargers and PC stand-by power. All three units allow the use of low-cost, EE16 core transformers. Typical conversion efficiency offered by a TinySwitch-based power converter is 70%-to-75%.

"The efficiency is constant all the way down to very-low power," states Power Integrations' vice president of engineering, Balu Balakrishnan. In PWM-based switchers, the losses stay fixed, as a result, the efficiency goes down with load, Balakrishnan says. By comparison, he adds, the TinySwitch skips cycles at low load to keep the switching losses lower and efficiency higher.

To simplify using TinySwitch devices in power-supply applications, Power Integration's engineers have readied several reference designs and application notes. These include a 1.5-W TV/VCR stand-by circuit, an 8-W PC stand-by supply, and a 3.5-W cellular phone charger. In addition, there is a 0.5-W off-line ac adapter. Evaluation boards are also available for these applications.



2. This functional block diagram shows that the TinySwitch controller packs an oscillator, Enable circuit, 5.8-V regulator, under-voltage circuit, hysteretic over-temperature protection, current limit, leading-edge blanking, and a 700-V lateral power MOSFET. This is made possible by the semiconductor supplier's proprietary 3.0 µm single metal CMOS process.

Price And Availability

The TinySwitch TNY253/254/255 devices are available in 8-pin DIP and 8-pin SMD packages. In 10,000-piece quantities, the prices range from $0.75 to $0.81 each.

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